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Updated Massachusetts Indoor Air Quality Threshold Values: A Case Study

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PART XII: Vapor Intrusion

Chapter 29

UPDATED MASSACHUSETTS INDOOR AIR QUALITY THRESHOLD VALUES: A CASE STUDY

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ABSTRACT

A sudden heating oil release occurred below a concrete slab of a residence in Massachusetts. The oil entered an open sump in the basement and migrated to a nearby stream. Remediation included deployment of absorbent booms, limited soil excavation, and in-situ treatment with hydrogen peroxide. Soil, sediment, groundwater, and indoor air samples were analyzed to delineate the extent of contamination, verify that remedial efforts were successful, and determine if a vapor intrusion pathway existed. Indoor air samples were collected on three events: at the time of release, after remedial activities, and four months later.

Indoor air analytical results were compared to the new draft Threshold Values published by the MassDEP Indoor Air Working Group (June 2008). In each sampling event, various compounds were detected above the applicable Threshold Values. As suggested by the MassDEP, multiple lines of evidence were investigated to determine whether the exceedances were attributable to the release. The presence of mothballs, the construction and operation of the home heating system, analytical evidence of a potential historical release, and soil and groundwater analytical data were used as lines of evidence that a vapor intrusion pathway did not exist.

Keywords: Indoor air quality, Threshold Values, typical indoor air concentrations, home heating oil, residence

1. INTRODUCTION

A spill of No. 2 fuel oil occurred in April 2007 in the basement of a Massachusetts residence when a technician accidentally stepped on, and broke, a transfer pipe to one of the two 330-

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gallon heating oil aboveground storage tanks (ASTs) in an unfinished part of the basement (Figure 1). Emergency efforts were undertaken that night to contain the spill in the basement.

An emergency response company was contracted by the responsible party to provide Immediate Response Actions (IRAs) under direction of Massachusetts Department of Environmental Protection (MassDEP) Emergency Response personnel. It was estimated by the emergency response company that approximately 85-160 gallons of fuel oil were released from the AST. The fuel oil spilled onto the competent and uncracked concrete slab floor of the basement, draining into an inactive 12-inch diameter gravel-filled sump located approximately 15 feet from the AST. The sump was an open gravel-filled conduit lined with a plastic pail without a pump. The fuel oil captured by the sump was believed to enter a french drain below the floor, which was connected to a 3-inch diameter perforated pipe that drained underground via gravity to a nearby catch basin (Figure 1).

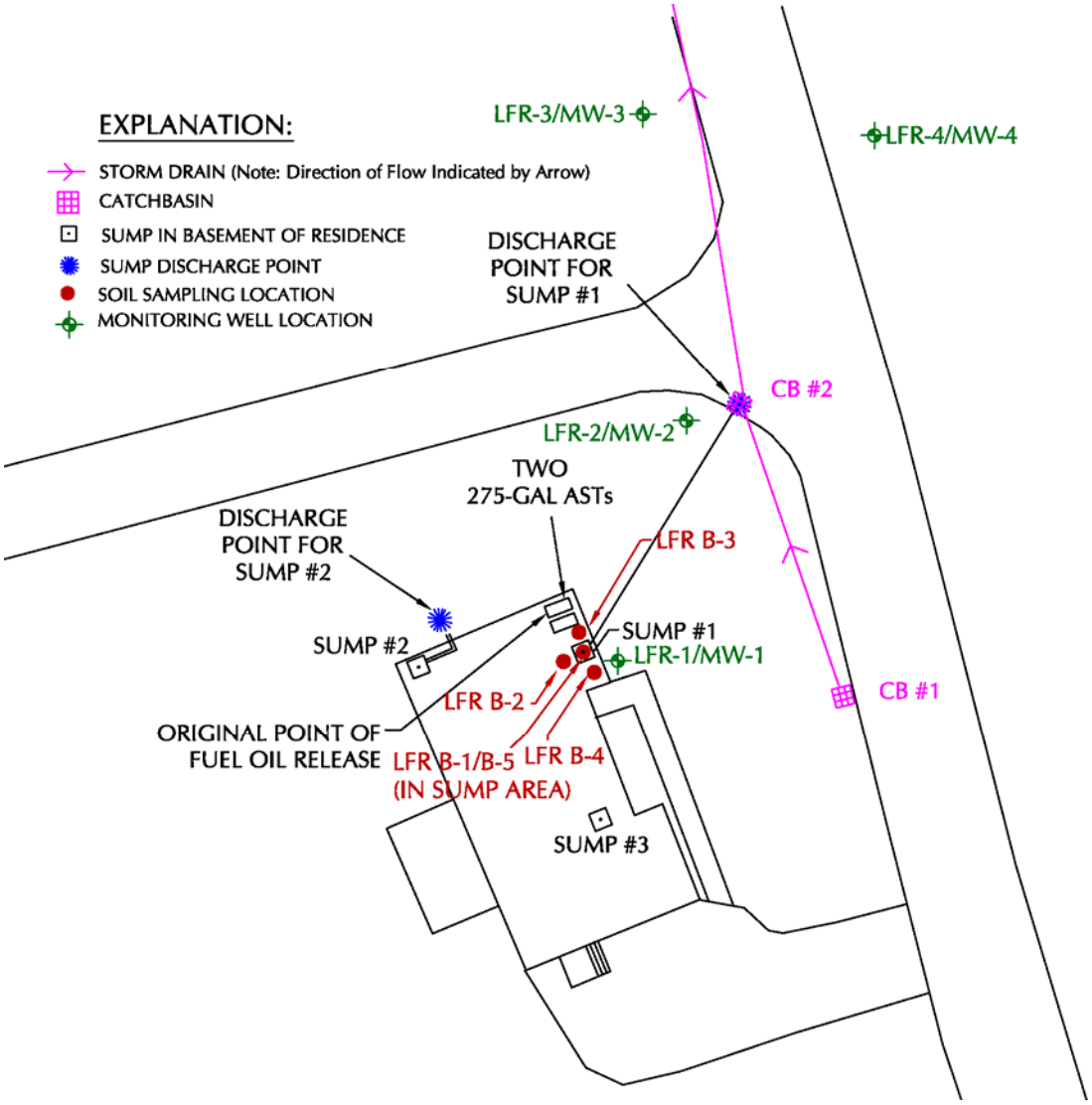

Figure 1. Site plan showing the point of the fuel oil release, the basement of the residence, and sampling locations.

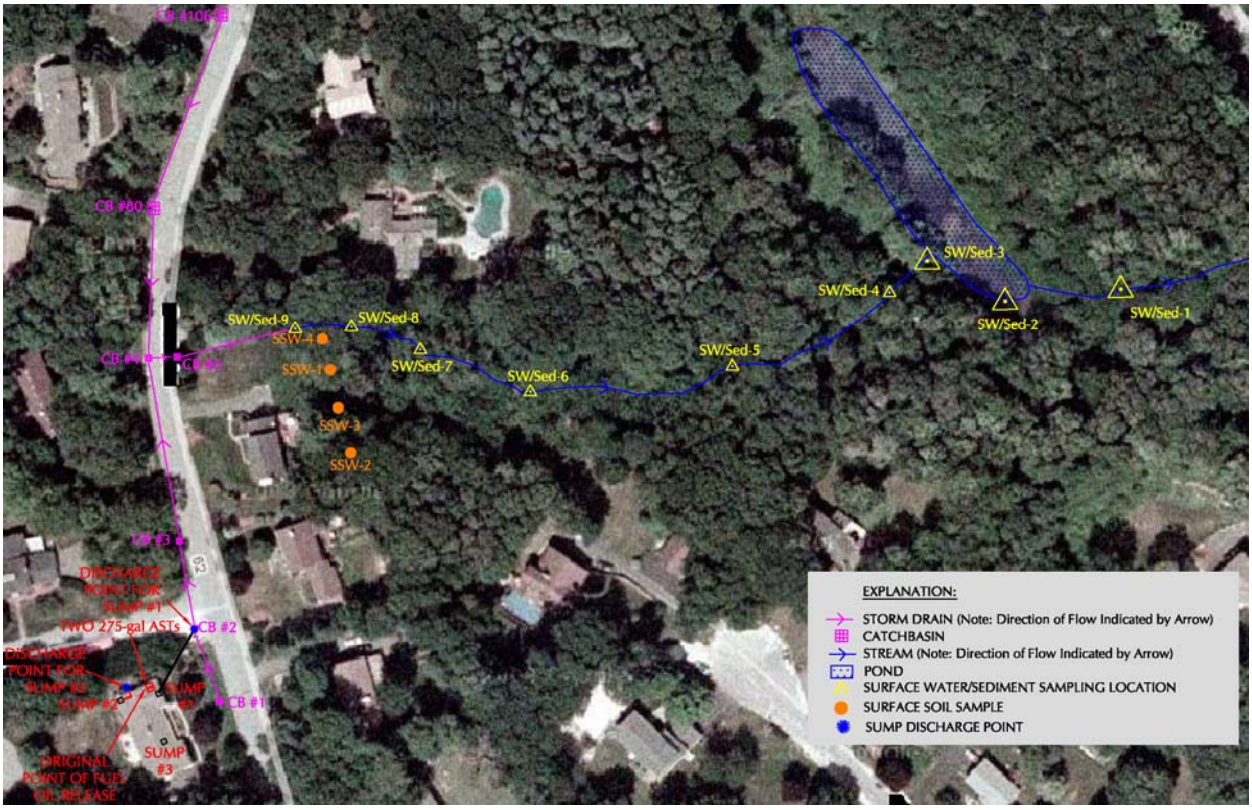

Figure 2. Site plan showing the catch basin network, and the affected nearby stream and lake.

Once the release reached the catch basin, it flowed north through solid drains, passing through two catch basins before discharging to a small stream. The stream discharged into a pond approximately 1/4 mile downstream (Figure 2), where a slight sheen was observed.

Emergency response actions included deployment of absorbent booms to collect oil present in the pond and stream and sediment sampling. The results indicated that initial efforts were successful to demonstrate that no deleterious affects were noted on the stream system. As such, subsequent efforts were focused on the basement and affected soil and groundwater.

In cases such as this, vapor intrusion is an issue that must be considered, evaluated, and mitigated if present. The presence of contaminants of concern (COCs) in soil and groundwater at significant concentrations directly below buildings can lead to the transfer of COCs from soil and groundwater into the vapor phase below the building. Many buildings, especially residences, are constructed with a sub-grade basement. The concrete floor slab of these basements is in direct contact with the vadose zone. If the floor slab has cracks in the concrete or holes to allow for utilities and/or sump pumps, a physical pathway exists for the migration of COC vapors from the vadose zone into the basement. Additionally, the act of heating and cooling the building creates a pressure differential between the vadose zone and the basement. This difference in pressure can promote the migration of COC vapors from the vadose zone into the building. This is commonly referred to as the "stack" effect (U.S. EPA, 2008). If conditions are right – COCs are present at

significant concentration in soil, groundwater and/or vapor; a physical pathway exists from the vadose zone into the basement; and if the chimney effect is applicable – potentially harmful concentrations of COCs can enter the basement and create what the MassDEP terms a Critical Exposure Pathway (CEP).

In general, the procedure for determining a CEP includes comparison of soil and groundwater concentrations to regulatory standards designed to indicate the potential presence of a CEP; a visual inspection of the basement and floor slab to determine if a physical pathway exists; sampling of vapors from the vadose zone to measure concentrations of COCs; and/or sampling of indoor air quality to measure concentrations of COCs. After the latter of these, indoor air analytical results are compared to the typical indoor air concentrations developed by the MassDEP. Significant concentrations of COCs can exist in indoor air from sources unrelated to a release of hazardous material into the environment. Common household components can release hazardous materials into air including off-gassing from furniture and carpets, household cleaners, automobiles in attached garages, etc. It is important to try and distinguish what concentrations are from a release and what concentrations are typical of indoor air to avoid unnecessary, inefficient, or unsuccessful remedial actions.

The MassDEP Indoor Air Working Group updated residential typical indoor air concentrations in June 2008 with a draft technical update entitled "Typical Indoor Air Concentrations" Technical Update (MassDEP, 2008a). This draft technical update is a work in progress and may change significantly before publication. Prior to this work, the MassDEP developed a list of background concentrations of volatile organic compounds (VOCs), volatile petroleum hydrocarbons (VPH), and extractable petroleum hydrocarbons (EPH) in residences (MassDEP 1994 and 2002). These were used as guidelines of what ranges of concentrations of VOCs, VPH, and EPH may be present at a site in the absence of a release. These values are based on the "United States Environmental Protection Agency (U.S. EPA) National Ambient VOC Database Update" (U.S. EPA, 1988) and a paper entitled "Assessment of Population Exposure and Carcinogenic Risk Posed by Volatile Organic Compound in Indoor Air" (Stolwijk, 1990). The new Typical Indoor Air concentrations are meant to update and expand upon this list. The Indoor Air Working Group reviewed analytical data from eight field studies in order to quantify typical indoor air concentrations of COCs caused by storage of household or consumer products, cigarette smoke, ambient air, the off-gassing of building materials, and other sources *not* related to a release of COCs to the environment. Depending on the study, COCs included those reported in the MassDEP Air Petroleum Hydrocarbon (APH) and/or TO-15 analytical methods. Typical Indoor Air concentrations were derived from the 50^{th}, 75^{th}, and 90^{th} percentile values calculated from the analytical data provided in the eight studies.

Out of this effort came the development of Threshold Values as detailed in the draft Technical Update entitled "Indoor Air Threshold Values for the Evaluation of a Vapor Intrusion Pathway" (MassDEP, 2008b), hereby referred to as the MassDEP Draft Technical Document. Threshold Values were determined for each COC as follows:

- The 90^{th} percentile value from the typical indoor air concentrations was identified.
- This value was compared to a risk-based concentration (RBC) calculated using an expected lifetime cancer risk of $1x10^{-6}$ and a hazard index of 0.2.

- If the RBC was greater than the 90th percentile value; the 90th percentile value was taken as the Threshold Value.

- If the RBC was less than the 90th percentile value, but greater than the 50th percentile value; the RBC was used as the Threshold Value.

- If the RBC was less than the 50th percentile value; the 50th percentile value was used as the Threshold Value.

- If the COC was not detected in the eight studies consulted, or was detected less than 10 percent of the time, the highest analytical reporting limit provided for MassDEP APH and TO-15 was used as the Threshold Value.

- However, if the reporting limit was greater than the RBC; the RBC was used as the Threshold Value.

In practice, Threshold Values can be compared to site-specific indoor air data to determine if further study is needed to evaluate the potential presence of a vapor intrusion pathway. In the case of residences, the presence of a vapor intrusion pathway is also considered a CEP that requires elimination or mitigation, to the extent feasible.

If the site-specific indoor air quality data are at or below the Threshold Values, MassDEP considers further investigation unnecessary. However, if site-specific indoor air quality data exceed the Threshold Values, it is presumed that a vapor intrusion pathway exists and multiple lines of evidence must be used to demonstrate otherwise.

LFR Inc. (LFR) investigated and remediated the subject heating oil release. Remediation included deployment of absorbent booms, collection of oil and affected water, limited soil excavation, and in-situ treatment with hydrogen peroxide. Remedial actions were conducted under emergency response and phased response actions as provided in the Massachusetts Contingency Plan (MCP). LFR collected soil, sediment, groundwater, and indoor air samples to delineate the extent of contamination, evaluate if remedial efforts were successful, and determine if a CEP existed. Results from water and soil samples showed that remedial efforts were successful. Indoor air sampling results taken at the time of release were indicative of a heating oil source; initial post-remedial sampling were consistent with the previously published background concentrations resulting from a non-heating oil source (such as gasoline from in-building storage of automobiles or use/storage of other petroleum based products). LFR was poised to close the case; however, comparisons to the new draft Threshold Values revealed exceedances. An extensive indoor air quality assessment was conducted including sample collection in multiple areas of the residence during different times of the year, removal of potential indoor petroleum sources (e.g., lawnmower, automobiles, fuel cans) prior to sampling, and a detailed survey of the presence of potential household contributors (e.g., mothballs, paint, home heating source).

2. MATERIALS AND PROCEDURE

LFR conducted soil, groundwater, and indoor air quality investigations at the residence. With respect to indoor air, LFR collected three indoor air samples shortly after the release in April 2007 using evacuated, passivated stainless steel canisters for analysis of APH. Samples were collected over a 24-hour period. Weather conditions on that day were 44ºF with rain. Conditions in the house were maintained as usual during sampling, with the windows closed. One sample was collected on the first floor near the kitchen (AS-3), one in the finished part of the basement (AS-2), and one in the unfinished part of the basement where the spill occurred (AS-1).

After remedial efforts were completed, LFR collected two indoor air samples for APH in November 2007 using evacuated, passivated stainless steel canisters equipped with 24-hour regulators (10:00 am to 10:00 am). Weather conditions on that day ranged from 30ºF to 41ºF and sunny. One sample was collected on the first floor in the kitchen (Kitchen) and one in the unfinished basement where the spill occurred (Basement). These were approximately co-located with the previous AS-3 and AS-1 samples, respectively.

A third, more extensive indoor air sampling event was conducted approximately four months later in March 2008. Forty-eight hours prior to the sampling event, LFR requested that the homeowner remove potential sources of COCs from the attached garage, including automobiles and a lawnmower. LFR collected four indoor and one outdoor air samples over a four hour period (8:00 am to 12:00 pm) for APH analysis. Weather conditions on that day were 34ºF and snowing. One sample was collected on the first floor in the kitchen (A3), one next to the doorway from the finished to the unfinished part of the basement (A2), one in the unfinished part of the basement near the ASTs (A1), one in the garage (A4), and one outdoors (A5). Concurrently, LFR conducted a survey of potential sources of COCs in the basement and the garage.

3. RESULTS AND DISCUSSION

LFR conducted three rounds of indoor air sampling: one prior to remedial efforts (April 2007), one shortly after remedial efforts (November 2007), and one four months later (March 2008). A summary of these results are presented in Table 1, alongside the draft Threshold Values.

Table 1. Indoor Air Quality Sampling Results

Sample Location	**Basement: Near Tanks/Burner**			**Basement: Other Side**		**First Floor**			**Garage**	**Outside**	**Threshold Values**
Date	4/2007	11/2007	3/2008	4/2007	3/2008	4/2007	11/2007	3/2008	3/2008	3/2008	
Benzene	ND	**5.94**	ND	ND	ND	ND	**7.44**	ND	ND	ND	2.3
Ethylbenzene	**13.4**	2.36	ND	2.65	ND	ND	6.45	ND	ND	ND	7.4
Total xylenes	**69**	5.16	ND	12.17	ND	8.11	**25.32**	ND	6.4	ND	20
Naphthalene	**71.2**	**3.41**	**18**	**8.79**	ND	**7.24**	ND	**5.5**	ND	ND	0.61
C5-C8 Aliphatics	**374**	**358**	50	**70.8**	**65**	**66.4**	**381**	**63**	33	ND	58
C9-C12 Aliphatics	**5950**	**147**	**110**	**277**	50	**215**	**193**	48	**69**	ND	68
C9-C10 Aromatics	**658**	ND	ND	**57.9**	ND	**35.4**	ND	ND	ND	ND	10

ND - Non-detect

All units are in micrograms per cubic meter ($\mu g/m^3$)

Bold indicates the value exceeds MassDEP Draft 2008 Threshold Values

In the April 2007 sampling event, prior to remedial efforts, Threshold Value exceedances were detected in all sampling locations for COCs such as ethylbenzene, total xylenes, naphthalene, and several petroleum hydrocarbon fractions. In the November 2007 sampling event, after remedial efforts, Threshold Value exceedances were detected for benzene, naphthalene, C5-C8 aliphatics, and C9-C12 aliphatics. At this time, soil samples collected did not contain concentrations of these compounds above the applicable S-1 MCP Method 1 Cleanup Standards (MassDEP, 1993) and groundwater concentrations were largely non-detectable. This included soil samples collected two months prior to the indoor air sampling event from the sump where the initial spill occurred. Under different circumstances, the absence of significant concentrations of these COCs in soil samples and groundwater would lead to closure using a Method 1 Risk Assessment (CMR 40.0941). However, due to the release within the footprint of the residence, it was necessary to demonstrate that the soil concentrations of the COCs were not likely to be a significant contributor to the Cumulative Receptor Risk Assessment combined with the Method 1 Risk Assessment (CMR 40.0941[1][d][1]). Site-specific indoor air or sub-slab vapor concentrations were needed to evaluate the potential for vapor intrusion. According to the MassDEP Draft Technical Document, (MassDEP, 2008b) these occurrences of Threshold Value exceedances suggested a vapor intrusion pathway potentially existed, and multiple lines of evidence would be needed to show otherwise.

In order to fully evaluate the potential for a vapor intrusion pathway LFR conducted a third, more extensive, indoor air sampling event in March 2008. At this time, the furnace system was operating normally and all windows were closed. Odors were noted in the basement from occasional wind-induced backflow conditions through the furnace exhaust flue. Data from this sampling event still included Threshold Value exceedances for naphthalene, C5-C8 aliphatics, and C9-C12 aliphatics in various locations (Table 1). In this case, it should be presumed that a vapor intrusion pathway exists unless multiple lines of evidence are used to demonstrate otherwise.

In addition to indoor air samples, a survey was conducted of potential sources of COCs. Materials present in the basement included 31 5-gallon latex paint cans, 20 cans of wood finish, a refrigerator, a washer/dryer, bleach, mink oil, fast plug cement, a box of mothballs, a hot water heater, an oil-fired furnace, and two 300-gallon fuel oil ASTs. LFR also noted the following in the garage: WD40™, Armor All™, a barbeque with propane cylinder, brake fluid, transmission fluid, Tough Stuff™, Ant-B-Gone™, d-Con™, weed preventer, fertilizer, car wash/wax, deer repellent, Miracle Grow™, and washer fluid.

The removal of potential COC sources prior to the March 2008 sampling event resulted in the decrease of several, typically gasoline-associated, compounds including benzene, ethylbenzene, total xylenes, and C5-C8 aliphatics (Table 1). This suggests that the previous indoor air concentrations of these COCs may have been influenced by the presence of an attached garage located next to the upstairs sampling point, where air was circulated by a forced-air heating system. The attached garage is used to store automobiles, a lawnmower, gasoline cans, etc. The idling of an automobile, even for a brief moment, during start up and parking, emits gasoline components into the garage atmosphere, which may potentially migrate into the living quarters. Other COCs were not significantly affected by the prior removal of household sources and may have been influenced by the remaining potential household sources (i.e., those noted in the inventory).

Based on the trends in concentrations and the site-specific circumstances (e.g., household materials present, heating source, and conditions), LFR concluded that the Threshold Value exceedances were not attributable to the No. 2 fuel oil release in April 2007. Below are the multiple lines of evidence LFR identified to refute the presence of a vapor intrusion pathway in the March 2008 sampling event, as directed by the MassDEP Draft Technical Document (MassDEP, 2008b). Pertinent soil and groundwater data referenced in the discussion is included in Tables 2 and 3.

Table 2. Pertinent Soil Analytical Results.

Sample	Depth	Date	BTEX	Naphthalene	C5-C8 Aliphatics	C9-C12 Aliphatics	C19-C36 Aliphatics	C9-C18 Aliphatics
	fbgs		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
B-1	3-5	6/7/07	NT	NT	NT	NT	27	17
B-1	5-7	6/7/07	NT	NT	NT	NT	ND<3.7	ND<3.7
B-1	1.5	6/15/07	NT	NT	NT	NT	ND<3.7	5.5
B-1	2.5-3	9/26/07	ND	ND<0.3	ND<1.5	ND<1.5	ND<3.8	6.7
B-2	1.5	6/26/07	NT	NT	NT	NT	ND<3.8	ND<3.8
B-3	1.5	6/26/07	NT	NT	NT	NT	61	81
B-3	1.5	9/26/07	ND	ND<0.28	ND<1.4	ND<1.4	ND<3.8	7.7
B-3	2.5-3	9/26/07	ND	ND<0.4	ND<2	ND<2	6.6	15
B-4	1.5	6/26/07	NT	NT	NT	NT	59	160
B-4	1.5	9/26/07	ND	ND<0.3	ND<1.5	ND<1.5	ND<3.6	ND<3.6
B-4	2.5-3	9/26/07	ND	ND<0.27	ND<1.3	ND<1.3	56	26
B-5	1.5	6/15/07	NT	NT	NT	NT	ND<3.7	ND<3.7
B-5	1.5	9/26/07	ND	ND<0.3	ND<1.5	ND<1.5	19	34
B-5	1.5	11/27/07	NT	NT	NT	NT	ND<0.38	4

fbgs – feet below ground surface
mg/kg – milligrams/kilogram
NT – Not Tested
ND<0.3 – Not Detected above reporting limit of 0.3 mg/kg

Table 3. Pertinent Groundwater Analytical Results.

Location ID	Date	BTEX	Naphthalene	C5-C8 Aliphatics	C9-C12 Aliphatics	C9-C10 Aromatics	C19-C36 Aliphatics	C9-C18 Aliphatics
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
SUMP#1	4/17/07	203*	97	ND<500	1,180	835	230	866
SUMP#1	5/9/07	NT	NT	NT	NT	NT	43,500	93,900
SUMP#1	6/7/07	NT	NT	NT	NT	NT	ND<100	110
SUMP#2	6/7/07	NT	NT	NT	NT	NT	ND<100	ND<100
SUMP#2	9/11/07	ND	ND<10	ND<100	ND<100	ND<100	NT	NT
SUMP#2	9/26/2007	ND	ND<10	ND<100	ND<100	ND<100	ND<100	ND<100
SUMP#2	11/27/07	ND	ND<10	ND<100	ND<100	ND<100	1600	200
CB#001	4/24/07	NT	NT	NT	NT	NT	ND<150	ND<150
CB#080	4/24/07	NT	NT	NT	NT	NT	250	ND<150
CB#106	4/24/07	NT	NT	NT	NT	NT	ND<150	ND<150
MW-1	6/15/07	NT	NT	NT	NT	NT	ND<100	ND<100
MW-1	8/29/07	ND	ND<10	ND<100	ND<100	ND<100	NT	NT
MW-1	9/26/2007	ND	ND<5	NA	NA	NA	ND<110	ND<110
MW-1	11/27/07	ND	ND<10	ND<100	ND<100	ND<100	120	ND<100
MW-1	3/1/08	NT	NT	NT	NT	NT	ND<150	ND<150
MW-2	7/13/07	NT	NT	NT	NT	NT	ND<100	ND<100
MW-2	8/29/07	ND	ND<10	ND<100	ND<100	ND<100	NT	NT
MW-2	9/17/07	NT	NT	NT	NT	NT	ND<100	ND<100
MW-2	9/26/07	ND	ND<10	ND<100	ND<100	ND<100	ND<100	ND<100
MW-2	11/27/07	ND	ND<10	ND<100	ND<100	ND<100	ND<100	ND<100
MW-2	3/1/08	NT	NT	NT	NT	NT	ND<150	ND<150
MW-3	7/13/07	NT	NT	NT	NT	NT	160	ND<110
MW-3	8/30/07	ND	ND<10	ND<100	ND<100	ND<100	NT	NT
MW-3	9/26/07	ND	ND<10	ND<100	ND<100	ND<100	ND<100	ND<100
MW-3	11/27/07	ND	ND<10	ND<100	ND<100	ND<100	ND<100	ND<100
MW-4	8/30/07	ND	ND<10	ND<100	ND<100	ND<100	ND<100	ND<100
MW-4	9/26/2007**	ND	ND<10	ND<100	ND<100	ND<100	ND<110	ND<110
MW-4	11/27/07	ND	ND<100	ND<1000	ND<1000	ND<1000	ND<100	ND<100

µg/L – micrograms per liter MW = Monitoring well BTEX – Benzene, Toluene, Ethylbenzene and Total Xylenes
NT – Not Tested CB = Catch basin ND – Not Detected, with reporting limits as available
* B< 20; T = 22; E = 26; X = 155 µg/L ** Samples collected on 9/26/07 and 10/3/07

3.1 Naphthalene

- If the presence of naphthalene is attributable to the subsurface release, it is likely to be detected in the affected soil or groundwater. Naphthalene has a relatively high aqueous solubility (~30 mg/l) and a low dimensionless Henry's constant (~0.02). A relatively high aqueous solubility and a low dimensionless Henry's constant indicate the COC is favorably detected in soil and groundwater, rather than air. In this case, naphthalene was detected in indoor air samples but not in soil or groundwater samples. This opposing situation suggests that the source of the naphthalene is not from affected soil or groundwater.

- The unfinished basement contains two oil tanks and a furnace with a release valve that allows small amounts of exhaust gas back into the basement on occasion. The home is heated by forced hot air, which recirculates the air through return registers located on the first floor.

- LFR analyzed soil samples from below the concrete slab in the basement, including total petroleum hydrocarbon fingerprinting. This analysis allows for identification of the source of the petroleum. The fingerprint analysis revealed the presence of two distinctly different petroleum types. The first was identified as No. 2 fuel oil (the material associated with the April 2007 release), and the other was identified as motor oil (not present in the April 2007 release). The presence of motor oil may be attributed to possible historical releases related to construction practices of the time or previous home owner disposal practices.

- An old box of Enos brand mothballs was stored in the basement and observed after the third round of indoor air sampling. Mothballs have historically contained high concentrations of naphthalene.

- Although the recent concentrations in indoor air samples exceeded Threshold Values, in a study of indoor air background in Massachusetts sites by Haley & Aldrich, Inc. as presented at the "RCRA Corrective Action Conference" in June 2006 (Rago et al., 2005), naphthalene was detected in 16 of 100 APH samples, ranging from 2.12 $\mu g/m^3$ to 41.5 $\mu g/m^3$. In comparison, the recent concentrations of naphthalene in indoor air at the site ranged from 5.5 and 18 $\mu g/m^3$. Of the 16 detected instances of naphthalene in the background study, six were homes with natural gas heat, nine were in homes with oil heat, and one was a home heated by propane. The three highest detected naphthalene concentrations in the background study were from homes heated with No.2 fuel oil. The subject residence is atypical in that it has two fuel oil ASTs. This poses a greater possibility of releases to air from openings, connections, and vents.

3.2 C5-C8 and C9-C12 Aliphatic Petroleum Ranges

- No C5-C8 aliphatics or C9-C12 aliphatics were detected in soil samples collected from the basement sump area where the spill occurred at various sampling events including as early as June 2007, shortly after the release occurred.

- No detectable concentration of C9-C18 aliphatics were found in the sediments sampled in the catch basins and the stream at the time of the release. While these data were collected using a different analytical method (i.e., EPH versus VPH) the C9-C12 aliphatic range is included within the larger C9-C18 aliphatic range.

- No detectable concentrations of C9-C18 aliphatics were found in soil during the drilling of four groundwater monitoring wells installed in the vicinity of the release shortly after the release occurred.

- No detectable concentrations of C5-C8 aliphatics and C9-C12 aliphatics via VPH analysis and C9-C18 aliphatics via EPH analysis were found in groundwater samples during several sampling events from June 2007 to March 2008.

- At one sampling event (April 2007) of the water present in the sump area where the release occurred, a detectable concentration of C9-C12 aliphatics (1.8 mg/l) was found however, results from all subsequent sampling events at this location did not detect C9-C12 aliphatics. C5-C8 aliphatics were not detected at any sampling events in this location.

- C5-C8 aliphatics are not present at significant concentrations in typical No. 2 fuel oil composition and C9-C12 aliphatics are of the lower carbon number range typically found in No. 2 fuel oil. Heavier (>C12) carbon range aliphatics are more common constituents. The detections of constituents found in the water from the sump area where the release occurred were relatively carbon-heavy, including C9-C18 aliphatics at 93.9 mg/l [with a low percentage of C9-C12 aliphatics at 1.9 percent], C19-C36 aliphatics at 43.5 mg/l, and C11-C22 aromatics at 35.8 mg/l.

- Lower-end carbon ranges (i.e., C5-C8 and some C9-C12) are typically found in lighter end petroleum products such as gasoline and other light petroleum products commonly found in households.

4. CONCLUSION

LFR investigated and remediated a No. 2 fuel oil release under the concrete slab in the basement of a residence in Massachusetts. Indoor air samples were collected shortly after the spill, after remediation, and four months later. At each of the sampling events, various COCs were detected at concentrations greater than the applicable Threshold Value. Indoor air quality sample results from the third sampling round still exhibited Threshold Value exceedances. However, using the multiple lines of evidence collected including analytical uncertainty, the presence of mothballs, the construction and operation of the home heating system, analytical evidence of a potential historical release of different oil and hazardous materials, and soil and groundwater analytical data, LFR was able to demonstrate to the MassDEP that a vapor intrusion pathway resulting from the April 2007 release no longer existed.

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